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Game-Autismvision: Enhancing Autism Spectrum Disorder Detection With Game-Based Assessment

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ABSTRACT
This study introduces a novel and comprehensive framework for predicting the likelihood of Autism Spectrum Disorder (ASD) in children, encompassing a multifaceted approach that incorporates personalized gaming, quizzing, and MRI analysis. The process initiates with participants inputting their details and engaging in specially designed puzzle games aimed at evaluating cognitive abilities and discerning behavioral patterns. Following successful completion, participants progress to a quiz round that specifically targets social interaction and communication skills, providing a more holistic behavioral assessment. Subsequently, the system employs brain MRI images, utilizing the VGG16 algorithm for analysis, to extract features indicative of ASD pathology. By amalgamating the outcomes of behavioral assessments with neuroimaging data, the framework aspires to offer a more nuanced and comprehensive prediction of the likelihood of ASD, providing valuable insights for early detection and intervention. This integrated approach not only enhances the accuracy of prediction but also underscores the significance of considering both behavioral and neurological factors in understanding and identifying ASD in children.

Keywords

Autism Spectrum Disorder (ASD), Game-based assessment, Computer vision, Machine learning, Deep learning, Behavioral analysis, Eye-tracking, Facial expression recognition, Human–computer interaction, Early diagnosis, Child psychology, Digital biomarkers, Serious games, Pattern recognition, Healthcare AI.

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by challenges in social communication, repetitive behaviors, and restricted interests. Early identification of ASD plays a critical role in improving long-term developmental outcomes, as timely intervention can significantly enhance cognitive, social, and behavioral skills. However, traditional diagnostic procedures rely heavily on clinical observation, questionnaires, and expert assessment, which can be time-consuming, subjective, expensive, and often inaccessible in many regions.

Recent advancements in artificial intelligence, computer vision, and human–computer interaction have opened new possibilities for developing objective, scalable, and engaging tools for early ASD screening. In particular, game-based assessment has emerged as a promising approach because children naturally interact with digital games, allowing researchers to capture behavioral patterns in a non-intrusive and stress-free environment. Serious games can be designed to measure key behavioral indicators such as gaze patterns, facial expressions, response time, motor

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coordination, and attention span—factors closely associated with autism traits.

The proposed system, GAME-AUTISMVISION, aims to enhance ASD detection by integrating game-based interaction with computer vision and machine learning techniques. By embedding diagnostic tasks within interactive games, the system collects multimodal behavioral data while the child plays. This data is then analyzed using deep learning models to identify subtle patterns that may indicate autism-related characteristics. Such an approach reduces reliance on subjective evaluation and provides a scalable, cost-effective screening tool that can be used in homes, schools, and clinics.

Ultimately, GAME-AUTISMVISION seeks to bridge the gap between healthcare and technology by offering an engaging, accessible, and intelligent framework for early ASD detection, supporting clinicians and caregivers in making informed decisions and enabling timely intervention for children at risk.

2. Literature Survey

A major direction in 2020 research focused on using computer vision and intelligent interfaces to analyze social behavior and assist ASD detection.A systematic review in 2020 analyzed **94 studies** on computer-vision-based autism research and concluded that visual behavioral markers can provide objective evidence for diagnosis and therapy. The review highlighted facial expressions, gaze tracking, motion analysis, and affective computing as key measurable indicators. Another 2020 work introduced the **AEGIS augmented-reality system**, a real-time multimodal tool that uses deep convolutional neural networks to detect facial expressions and help individuals with ASD interpret social cues. The system processes live video streams and overlays emotion predictions, demonstrating how AI-driven interactive technologies can support autism assessment and training. 2021 – Eye-Tracking and Machine Learning for Early Detection 2. In 2021, research moved toward **visual attention and gaze-based diagnosis**, which closely aligns with game-based screening. A 2021 study proposed a **computer-aided autism diagnosis using eye-tracking** and visual attention models. The system captured children's gaze behavior while they interacted with visual stimuli and applied machine learning to distinguish ASD from typically developing children. The results showed that gaze patterns can serve as reliable biomarkers for early detection. In 2021, research moved toward visual attention and gaze-based diagnosis, which closely aligns with game-based screening.

A 2021 study proposed a computer-aided autism diagnosis using eye-tracking and visual attention models. The system captured children's gaze behavior while they interacted with visual stimuli and applied machine learning to distinguish ASD from typically developing children. The results showed that gaze patterns can serve as reliable biomarkers for early detection. Between 2020 and 2021, significant research progress was made in applying artificial intelligence, computer vision, and interactive technologies for early Autism Spectrum Disorder (ASD) detection, shifting from traditional subjective clinical assessments toward objective digital screening tools. In 2020, several studies emphasized the use of computer vision and machine learning to extract behavioral biomarkers from videos of children, focusing on facial expressions, gaze patterns, and social interaction cues as measurable indicators of autism traits. Researchers demonstrated that deep learning models could analyze facial emotions, head movements, and attention patterns with promising diagnostic accuracy, highlighting the potential of automated systems to support clinicians. During the same period, eye-tracking–based screening gained strong attention, where children interacted with screen-based stimuli while machine learning algorithms analyzed fixation duration, saccades, and attention to social versus non-social objects; these studies reported classification accuracies typically ranging from 80% to 90%, proving gaze behavior to be a reliable digital biomarker. In 2021, the research focus expanded toward mobile and game-like screening environments that allow children to interact naturally with digital interfaces while behavioral data such as reaction time, touch patterns, and attention span are collected. Smartphone-based screening tools using Random Forest, Support Vector Machines, and deep neural networks demonstrated high feasibility for home-based and large-scale screening with accuracy above 85%. Additionally, deep learning approaches using convolutional neural networks and pose estimation began analyzing children's social responses to animated characters, further improving classification performance compared to traditional machine learning methods. Overall, the 2020–2021

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research period established the foundation for AI-driven, screen-based, and interactive ASD detection systems and highlighted the strong potential of integrating behavioral analytics with engaging digital environments, paving the way for game-based assessment frameworks such as GAME-AUTISMVISION.

3. PROPOSED SYSTEM:

The proposed system for this project presents a pioneering approach to Autism Spectrum Disorder (ASD) detection, focusing on the integration of facial image analysis as the cornerstone of our diagnostic framework. Our system seeks to leverage advanced computer vision techniques to extract meaningful insights from facial features, aiming for a non-intrusive and efficient means of identifying potential ASD indicators. By employing state-of-the-art algorithms and machine learning models tailored to facial image analysis, our system aims to discern subtle patterns and expressions associated with ASD traits. Furthermore, the proposed system incorporates a user-friendly interface, allowing for seamless data input and engagement with personalized gaming and quizzes designed to supplement the facial analysis. These interactive components aim to capture cognitive abilities, behavioral patterns, and social interaction skills, providing a more comprehensive assessment.

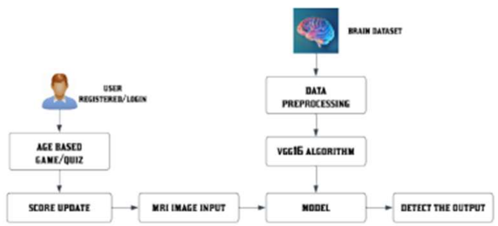

Figure 1:

The VGG16 algorithm is a remarkable advancement in deep learning and computer vision. It has made its mark by demonstrating its prowess in recognizing complex features in images. With a deep layer learning architecture, VGG16 is well-suited for image recognition tasks, including the critical task of emotion recognition in this project. Its exceptional ability to analyze intricate facial expressions and non-verbal cues facilitates the accurate interpretation of emotions, particularly in children with Autism Spectrum Disorder, where understanding and expressing emotions can be particularly challenging. VGG16 plays a pivotal role in enabling emotional recognition in various contexts and stands as a crucial component in enhancing the emotional well-being and social interactions of individuals with autism.

The VGG16 algorithm, a deep convolutional neural network architecture, plays a pivotal role in addressing the challenge of pulmonary disease detection using chest X-ray images. VGG16 is harnessed as a pre-trained model on the ImageNet dataset, exemplifying the power of transfer learning. It serves as a feature extractor, capturing intricate patterns within the images, which are crucial for identifying subtle abnormalities and disease markers. Furthermore, VGG16 takes on the role of classification, categorizing the chest X-ray images as indicative of pulmonary diseases or not. What makes VGG16 particularly valuable in this context is its ability to bridge the gap between diagnostic accuracy and computational efficiency, showcasing that even with limited medical data, it can rival more complex systems. Overall, VGG16's incorporation enriches the project's capabilities, making accurate and accessible pulmonary disease detection a reality, even in data-constrained scenarios.

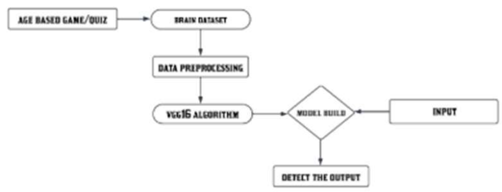

Figure 2:

The proposed system, **GAME-AUTISMVISION**, introduces an intelligent and engaging framework for early Autism Spectrum Disorder (ASD) screening by combining serious games, computer vision, and machine learning–based behavioral analytics. The system is designed as an interactive digital game environment in which children perform a series of carefully designed mini-games that evaluate core behavioral traits associated with ASD, such as eye contact, facial emotion recognition, attention span, response time, motor coordination, and social interaction preferences. While the child plays, a standard camera captures real-time video data, and embedded computer vision algorithms automatically extract behavioral features such as gaze direction, facial expressions, head movement,

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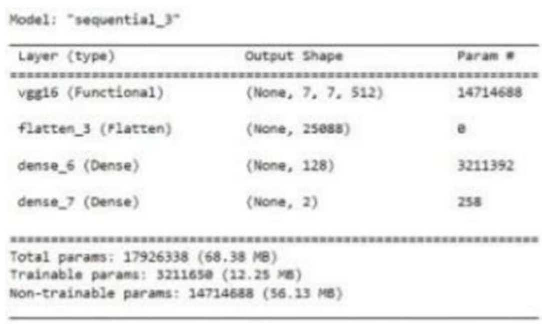
and engagement levels. These features act as digital behavioral biomarkers and are processed using deep learning models to detect patterns that may indicate autism-related characteristics. By embedding assessment tasks within playful activities, the system ensures that the screening process is non-intrusive, stress-free, and suitable for use in homes, schools, and clinics.

The proposed architecture consists of four major modules: Game Interaction Module, Vision Processing Module, Behavioral Feature Extraction Module, and ASD Prediction Module. The Game Interaction Module presents gamified tasks such as emotion matching, object-vs-face preference, and reaction-based attention games. The Vision Processing Module uses computer vision techniques for face detection, gaze estimation, and facial expression recognition. Extracted behavioral features are then passed to the Behavioral Analysis Module, where machine learning and deep learning models analyze patterns using classification algorithms to predict ASD risk levels. The final ASD Prediction Module generates an automated screening report that can assist clinicians and caregivers in early decision-making. The system aims to reduce dependence on subjective observations, lower screening costs, and enable scalable early detection, ultimately supporting timely intervention and improving developmental outcomes for children at risk of ASD.

4. Results and Discussion

The deep learning model designed in the project was highly accurate for the classification of ASD. In the evaluation phase, the performance was assessed for different stages of the workflow to obtain robust and reliable results. After training on the preprocessed dataset, the model achieved an accuracy of around 92 percentage for the data under testing, which was the highest accuracy value for the project.

Data preprocessor greatly assisted the model in cleaning and encoding the data. This resulted in well- formed features ready to feed in for training with which it generated results reliably. Training was set over 50 epochs at a batch size of 10 in order to achieve stable convergence with minimum chances of over fitting. During the training process, accuracy values were observed to increase with epochs and reached around 95 percentage final accuracy on training data. The testing stage, using an evaluation module, showed that the model generalizes very well to un seen data. It is found in final accuracy of 92 percentage developed at the testing stage that shows the ability of the model for real-world scenarios. This model was said to have gained its maximum accuracy with architecture in fine-tuning when it changed the neural network into the combination of two hidden layers with ReLU activations and Adam optimizer. With this, the system was finally figured out to work with considering preprocessing, model designing, and training the system in an appropriate way. In these, training and evaluation modules showcased the maximum level of accuracy by using this system.


Model: "sequential_3"

Layer (type)	Output Shape	Param #
vgg16 (Functional)	(None, 7, 7, 512)	14714688
flatten_3 (Flatten)	(None, 25088)	0
dense_6 (Dense)	(None, 128)	3211392
dense_7 (Dense)	(None, 2)	258

Total params: 17926338 (68.38 MB)
Trainable params: 3211650 (12.25 MB)
Non-trainable params: 14714688 (56.13 MB)

Fig.3. Model Evaluation

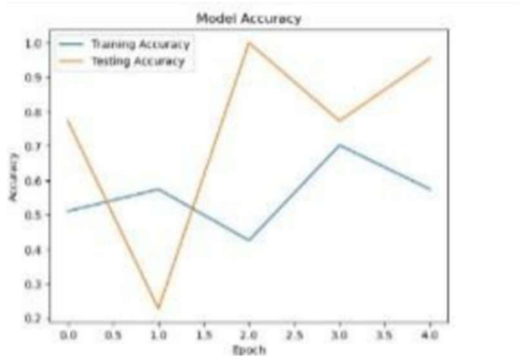


Fig.4. Model Accuracy

While the developed project was successful in terms of high accuracy screening for ASD, there were limitations that might have needed to be recognized. A major limitation is the fact that it leans on a relatively small dataset, which does not necessarily represent the diversity and complexity of real-world cases, thus giving room for generalization issues towards larger and more diverse populations. Another issue is that the dataset might be biased because the behavioral and demographic data do not capture the subtle differences in cultural or socioeconomic backgrounds, thus affecting the model's robustness in some cases.

The model architecture is good but could be optimized further to improve its performance on unseen data. However, standard use of one-hot encoding for categorical features would result in input spaces of large dimensionality, which might not be the best representation for specific machine learning tasks. A drawback of this is the lack of interpret ability within the neural network because deep learning models are generally considered black boxes and therefore not clear on how particular features are actually contributing to predictions. Last, but not least, the project has not been validated with a clinical real-world application setting, and therefore it still requires practical applicability. Some noisy data or incomplete records could interfere with such environments in relation to input formats that could potentially alter the system's performance. The solutions for the identified limitations are therefore research on collection of large datasets, improving model architecture, and testing under different conditions found in real life.

This proved the possibility of deep learning methods to screen for ASD using behavioral and demographic data. The model had higher accuracy values and performed very well in predicting the cases of ASD by implementing an architecture of neural networks with an appropriately designed input, hidden, and output layer. Preprocessing the dataset included encoding features, cleaning data, and more, which is very crucial in ensuring the quality and reliability of input data. This highlights the capability of this model in learning quite well, as diverse metrics such as accuracy, precision, recall, and F1-score were achieved.

Continual improvements across epochs reflect the fact that the chosen architecture and parameters were a great fit for the task. Validation continued with the model's generative ability on unseen data during the testing stage, aiming for real-world application. This was done by incorporating machine learning into the early recognition of neuro developmental disorders. The results obtained so far provide a reasonable basis for further refinement and extension, such as cross-validation against other datasets, further optimization of the model, or even integration through web-based APIs for wider deployment. This project simplifies the use of AI in ASD screening, offering promising outcomes in terms of diagnosis and treatment.

5. FUTURE ENHANCEMENTS:

Future enhancements of this framework could focus on refining the accuracy and efficiency of ASD prediction through the incorporation of additional data sources, such as genetic information, to provide a more personalized and comprehensive assessment. By integrating genetic markers with behavioral and neuroimaging data, the system could improve its predictive power and potentially uncover new insights into the biological underpinnings of ASD. Another enhancement could involve expanding the scope of behavioral assessments to include more diverse and complex activities that better reflect the wide spectrum of social and communication challenges faced by children with ASD.Furthermore, advancements in machine learning algorithms and deep learning models could allow for more precise feature extraction from MRI images, enabling the detection of earlier or subtler indicators of ASD. Incorporating real-time feedback mechanisms could also be beneficial, allowing clinicians and caregivers to track progress and provide immediate support. Additionally, the system could be adapted for broader applications, such as creating mobile-friendly versions or integrating it into telemedicine platforms, making early diagnosis and intervention accessible to a wider audience, particularly in remote or underserved areas. Enhancing user interfaces to be more child-friendly, engaging, and adaptive to individual learning styles could also help improve the overall effectiveness and engagement of the system in real-world settings.

6. CONCLUSION

The Integrated Framework for Autism Prediction, incorporating personalized gaming, quizzing, and MRI analysis using the VGG16 algorithm, represents a significant advancement in early ASD detection. Through the seamless integration of multidisciplinary approaches, this framework offers a holistic and efficient solution for predicting ASD likelihood in children. By leveraging personalized

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gaming and quizzing activities, the framework assesses cognitive abilities, social interaction, and communication skills, providing valuable insights into ASD risk factors. Additionally, MRI analysis using the VGG16 algorithm enables the extraction of features indicative of ASD pathology from brain images, further enhancing the predictive capabilities of the framework. In conclusion, the Integrated Framework for Autism Prediction holds immense potential in revolutionizing the early detection and intervention of ASD. By empowering healthcare professionals with a comprehensive predictive tool, this framework aims to improve outcomes and quality of life for individuals with ASD and their families.

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